Contents

Preface xv
K. Lüders and R. Schöllhorn, Berlin, F.R.G.

Section I: Synthesis and Reaction Mechanisms

Novel aspects of graphite intercalation by fluorine and fluorides and new B/C, C/N and B/C/N materials based on the graphite network (Invited) 1
J. Kouvetakis, T. Sasaki, C. Shen, R. Hagiwara, M. Lerner, K. M. Krishnan and N. Bartlett (Berkeley, CA, U.S.A.)

Cesium–antimony and cesium–arsenic intercalated graphite: synthesis and reaction mechanisms (Invited) 9
P. Lagrange, A. Essaddek and J. Assouik (Vandoeuvre-lès-Nancy, France)

Intercalation reactions in molten salt systems (Invited). 15
M. Inagaki (Toyohashi, Japan)

Thermodynamic conditions of intercalation. The role of temperature and entropy 21
A. Hérold (Vandoeuvre-lès-Nancy, France)

Synthesis, crystallographic study and electrical conductivity of GICs with alkali metal hydrides 27
D. Guérard, L. Elansari, N. E. Elalem, J. F. Marêché and E. McRae (Vandoeuvre-lès-Nancy, France)

Temperature induced collapse of the $Li(THF)_x$ complexes in the $Li(THF)_{2.13}C_{12}$ graphitide 33
F. Béguin, M. Goldmann (Orléans, France) and D. Guérard (Vandoeuvre-lès-Nancy, France)

New ternary alkaline earth metal–ammonia compounds 41
M. Höhne, Y. X. Wang, E. Stumpp and H.-J. Hummel (Clausthal-Zellerfeld, F.R.G.)

Synthesis, stability and structure of GIC with Li, Na and K 47
I. T. Belash, O. V. Zharikov and A. V. Palnichenko (Chernogolovka, U.S.S.R.)

High stage graphite intercalation compounds of rare earth metals and alkali-metal vapor-transport technique 53
T. Takamoto, H.. Suematsu and Y. Murakami (Tokyo, Japan)

High temperature physintercalation into the 2nd stage CsC_{24} 59
M. Goldmann, F. Béguin (Orléans, France) and H. Pilliere (Grenoble, France)

Observations on staging in the intercalation of metal chlorides in graphite 67
P. Schoderböck and H. P. Boehm (Munich, F.R.G.)

Preparation of metal halide graphite intercalation compounds by intercalate exchange. 73
E. Stumpp, P. Schubert and C. Ehrhardt (Clausthal-Zellerfeld, F.R.G.)

Electrointercalation of tetrahedral $AlCl_4^-$ and $GaCl_4^-$ anions into graphite. 79
D. Billaud and A. El Haouari (Vandoeuvre-lès-Nancy, France)

Investigations of the nucleation process of metal chloride–graphite intercalation compounds 85
W. Metz and M. Shamsrizi (Hamburg, F.R.G.)

The system graphite/indium chloride/chlorine: threshold pressures and intercalate nucleation 91
M. Shamsrizi and W. Metz (Hamburg, F.R.G.)

Chemical and electrochemical reduction of graphite intercalation compounds of metallic fluorides. 97
A. Hamwi, S. Mouras and J. C. Cousseins (Aubière, France)

Preparation and characterization of tungsten oxide fluoride and tungsten fluoride–graphite intercalation compounds. 103
T. Nakajima and M. Molinier (Kyoto, Japan)

Fluoride/fluoride and fluoride/sulfuric acid graphite bi-intercalation compounds 109
R. Yazami and T. Nakajima (Kyoto, Japan)

The graphite nitrate compounds: graphite–N_2O_5 system. 115
H. Fuzellier, M. Lelaurain and J.-F. Marêché (Vandoeuvre-lès-Nancy, France)

Upon the reactions of hydrous nitrate melts with graphite. 121
P. Scharff, E. Stumpp and C. Ehrhardt (Clausthal-Zellerfeld, F.R.G.)

Intercalation of molybdenum oxide nitrate in graphite 127
E. Stumpp, H. Griebel and H.-J. Hummel (Clausthal-Zellerfeld, F.R.G.)

Hydrolysis of perchloric acid and sulfuric acid graphite intercalation compounds 133
J. O. Besenhard, P. Minderer (Münster, F.R.G.) and M. Bindl (Munich, F.R.G.)

Potential survey of intercalation of sulfuric acid into graphite by chemical oxidation 139
N. Iwashita and M. Inagaki (Toyohashi, Japan)

The formation of graphite intercalation compounds from trichloroacetic acid and trichloroacetic acid chloride solutions containing molybdenum compounds 145
F. Schulz, P. Behrens and W. Metz (Hamburg, F.R.G.)

Preparation and properties of vapor grown graphite 151
J. Shioya, A. Mizoguchi, Y. Yamaguchi and N. Yasuda (Tokyo, Japan)

Formation of graphite oxide 157
M. Mermoux and Y. Chabre (Saint Martin d'Hères, France)

Section II: Structural Aspects

X-ray diffraction and computer simulations for partially disordered systems (Invited) 165
F. Rousseaux (Bagneux, France), D. Guérard, P. Lagrange, R. Vangélisti, N. E. Nadi, M. Lelaurain and A. Hérold (Vandoeuvre-lès-Nancy, France)

Surface structure of graphite intercalation compounds resolved in real space by scanning tunneling microscopy (Invited) 175
R. Wiesendanger, D. Anselmetti, V. Geiser, H. R. Hidber and H.-J. Güntherodt (Basel, Switzerland)

Structure, *c*-axis resistivity, and p–T phase diagrams of $SbCl_5$ intercalated graphite 187
O. E. Andersson, B. Sundqvist (Umeå, Sweden), M. Lelaurain, J.-F. Marêché and E. McRae (Vandoeuvre-lès-Nancy, France)

In-plane structure of the state-2 $SbCl_5$ graphite intercalation compounds 193
K. Otobe, R. Nishitani and Y. Nishina (Sendai, Japan)

Graphite intercalation compounds of $PdCl_2$: structural investigations 199
P. Behrens, J. Ehrich, W. Metz (Hamburg, F.R.G.) and W. Niemann (Lyngby, Denmark)

High stage hetero-structure graphite intercalation compounds in the acceptor ($MoCl_5$) and donor (potassium) ternary system 205
Y. Murakami, T. Kishimoto, H. Suematsu (Tokyo, Japan), R. Nishitani, Y. Sasaki and Y. Nishina (Sendai, Japan)

Structure of stage-1 and stage-2 MCl_2 GICs. 211
J. S. Speck and M. S. Dresselhaus (Cambridge, MA. U.S.A.)

X-ray absorption spectroscopy and X-ray diffraction of $AuCl_3$–graphite 217
J. Ehrich, P. Behrens, W. Metz (Hamburg, F.R.G.) and W. Niemann (Lyngby, Denmark)

Structural characteristics of the graphite intercalation compounds of metal chlorides 223
P. Behrens and W. Metz (Hamburg, F.R.G.)

Local environment of Sn in tin fluoride–GIC 231
A. Tressaud, T. Roisnel, L. Fournes, J. Grannec (Talence, France), H. Touhara, H. Imoto (Kyoto, Japan) and H. Dexpert (Orsay, France)

Structural factors on stability of fluoride– or fluorine–graphite intercalation compounds 237
T. Nakajima, K. Okahara and T. Matsui (Kyoto, Japan)

c-Axis lattice expansion in ternary intercalated layered solids. 243
S. A. Solin, S. Lee, H. Miyazaki and S.D. Mahanti (East Lansing, MI, U.S.A.)

Structural study of two graphite–cesium–arsenic lamellar alloys (stages 1 and 2) 249
J. Assouik and P. Lagrange (Vandoeuvre-lès-Nancy, France)

Structure of the intercalated metallic sheets in the lamellar graphite–cesium–antimony phases 255
A. Essaddek, P. Lagrange (Vandoeuvre-lès-Nancy, France) and F. Rousseaux (Bagneux, France)

Local structure in the ternary alkali metal–graphite compound $K_{1-x}Rb_xC_8$ studied by X-ray absorption. 261
W. Krone, G. Wortmann, G. Kaindl (Berlin, F.R.G.) and H. Zabel (Urbana, IL, U.S.A.)

Structure of an electrochemical reduced graphite–cobalt compound 267
G. K. Nguessan and Ph. Touzain (Saint Martin d'Hères, France)

Staging disorder in graphite intercalation compounds 273
F. Rousseaux, G. Besson, C. Tchoubar, I. Rannou (Orléans, France) and D. Guérard (Vandoeuvre-lès-Nancy, France)

The Madelung energy and Madelung constant of real and of hypothetical first stage graphite intercalation compounds. 279
R. Setton (Orléans, France)

A new correction factor for X-ray intensities in structural investigations of graphite intercalation compounds. 285
J. Ehrich and W. Metz (Hamburg, F.R.G.)

Section III: Kinetics, Dynamics and Phase Transitions

Graphite and graphite intercalation compounds under pressure: Raman modes, optical reflectivity, and phase changes (Invited). 293
K. Syassen, M. Hanfland, H. J. Beister (Stuttgart, F.R.G.) and R. Sonnenschein (Düsseldorf, F.R.G.)

Interlayer spacing and lattice-gas melting of ternary GICs (invited) 307
S. D. Mahanti (East Lansing, MI, U.S.A.)

Kinetics of staging transition in H_2SO_4–graphite intercalation compounds (Invited) 315
R. Nishitani, Y. Sasaki and Y. Nishina (Sendai, Japan)

Kinetics of the first-order transition in stage 1 rubidium graphite intercalation compound 323
N. Metoki, H. Suematsu, Y. Murakami (Tokyo, Japan), Y. Ohishi and Y. Fujii (Toyonaka, Japan)

Formulation of isotherms for low-temperature absorption of H_2 and D_2 on KC_{24} prepared from natural graphite 329
T. Terai and Y. Takahashi (Tokyo, Japan)

Ultrasonic investigations of the kinetics of ordering in $SbCl_5$-intercalated graphite 335
K. de Groot, D. Maurer, V. Müller (Berlin, F.R.G.), V. Geiser and H.-J. Güntherodt (Basel, Switzerland)

In situ observation of X-ray diffraction in a synthesis of H_2SO_4–GICs 341
Y. Yosida, S. Tanuma (Iwaki, Japan) and K. Okabe (Gunma, Japan)

Lattice dynamics of alkali graphite intercalation compounds 347
H. C. Gupta, J. Malhotra, N. Rani and B. B. Tripathi (New Delhi, India)

Structure and dynamics of C_8AsF_5: a neutron scattering study 353
D. Vaknin, J. E. Fischer, D. Djurado, J. Ma (Philadelphia, PA, U.S.A.) and J. W. Milliken (Washington, DC, U.S.A.)

Pressure-induced phase transitions of graphite–bromine intercalation compounds 359
S. Matsuzaki, T. Kyouda, M. Arimitsu and M. Sano (Kumamoto, Japan)

Phase transitions above room temperature in first stage graphite–cesium–antimony intercalation compounds. 365
A. Essaddek, M. Lelaurain, J. F. Marêché, E. McRae and P. Lagrange (Vandoeuvre-lès-Nancy, France)

Section IV: Electronic Structure

Magneto-quantum and topological studies on Fermi surface of GICs (Invited) 373
Y. Yosida and S. Tanuma (Iwaki, Japan)

Electronic structure of AsF_5 intercalated graphite from de Haas–van Alphen measurements. 381
W. Joss, J. M. van Ruitenbeek, I. D. Vagner (Grenoble, France), F. Jost, F. Rachdi and S. Roth (Stuttgart, F.R.G.)

De Haas–van Alphen effect in stage 2 $CuCl_2$–graphite intercalation compound 387
Y. Yosida (Iwaki, Japan)

Theory of the de Haas–van Alphen effect in quasi-two-dimensional conductors 393
I. D. Vagner, T. Maniv, W. Joss, J. M. van Ruitenbeek and K. Jauregui (Grenoble, France)

Charge transfer in acceptor graphite intercalation compounds 399
S. Flandrois, C. Hauw (Talence, France) and R. B. Mathur (New Delhi, India)

^{129}I Mössbauer study of the charge transfer in ICl– and IBr–graphite intercalation compounds 405
M. Tiedtke and G. Wortmann (Berlin, F.R.G.)

Nature of empty states in cesium intercalated graphite 411
G. Loupias, V. Codazzi (Paris, France), S. Rabii, R. C. Tatar (Philadelphia, PA, U.S.A.), I. Ascone, D. Guérard and L. Elansari (Vandoeuvre-lès-Nancy, France)

Ellipsometry of graphite and C_8K intercalation compound between 5 and 30 eV 417
D. Fuchs, R. Schlögl, A. M. Bradshaw (Berlin, F.R.G.), J. Barth, R. L. Johnson and M. Cardona (Stuttgart, F.R.G.)

Information about the band structure of LiC_6 from inelastic synchrotron X-ray scattering. 423
W. Schülke, A. Berthold and A. Kaprolat (Dortmund, F.R.G.)

Band structures of ternary intercalation compounds C_8KH_x 429
S. Mizuno and K. Nakao (Tsukuba, Japan)

Section V: Electronic Properties, Phonons

The measurement of intercalant vibrations using Raman and infrared spectroscopies (Invited) 437
Y. Yacoby (Jerusalem, Israel)

Polarization dependence of the infrared-active modes of pyrolytic graphite (HOPG) and a potassium–HOPG intercalation compound 443
J. Heidberg, W. Lassmann, M. Warskulat (Hannover, F.R.G.) and M. Folman (Haifa, Israel)

Anisotropic superconductivity in C_4KHg–GICs 449
M. S. Dresselhaus, A. Chaiken and G. Dresselhaus (Cambridge, MA, U.S.A.)

Superconductivity of GIC with Li, Na and K 455
I. T. Belash, O. V. Zharikov and A. V. Palnichenko (Chernogolovka, U.S.S.R.)

Experimental evidence of the possible origins of high temperature superconductivity by NMR studies of fluorinated $YBa_2Cu_3O_x$ samples. Teaching for graphite compounds 461
J. Conard (Orléans, France), C. Perrin, O. Pena, M. Sergent and G. Fonteneau (Rennes, France)

In-plane conductivity of electrochemically intercalated pyrographite. 467
A. Harrach, C. Nicollin and A. Métrot (Reims, France)

Transport studies on some metal chloride intercalated graphites and the corresponding bi-intercalation compounds 473
P. Pernot, J. F. Marêché, E. McRae, R. Vangélisti (Vandoeuvre-lès-Nancy, France), M. Kinany-Alaoui, L. Piraux, V. Bayot and J.-P. Issi (Louvain-la-Neuve, Belgium)

Low field Hall effect in $FeCl_3$ graphite intercalation compounds 479
A. I. Abou Aly, R. Awad, I. H. Ibrahim (Alexandria, Egypt), A. K. Ibrahim, G. O. Zimmerman, R. E. Powers and M. Z. Tahar (Boston, MA, U.S.A.)

c-Axis resistance of $HgCl_2$ intercalated graphite as a function of temperature and pressure. 485
O. E. Andersson, B. Sundqvist (Umeå, Sweden) and P. Behrens (Hamburg, F.R.G.)

Effect of microcrystalline structure on the transport properties of pristine and AsF_5-intercalated, highly-oriented, pyrolytic graphite. 491
W. Lang (Vienna, Austria)

Effect of Cs and Ba adsorption on the electronic properties of carbon films adsorbed on metals (Ir, Re) 497
N. R. Gall, S. N. Mikhailov, E. V. Rut'kov and A. Ya. Tontegode (Leningrad, U.S.S.R.)

Section VI: Magnetism and Magnetic Resonance

Spin fluctuations and excitations in a 2D XY-ferromagnet: $CoCl_2$ in graphite (Invited) 505
D. G. Wiesler, H. Zabel (Urbana, IL, U.S.A.) and S. M. Shapiro (Upton, NY, U.S.A.)

Magnetism of $CoCl_2$ intercalated in graphite studied by elastic and inelastic neutron scattering. 513
J. Rogerie, Ch. Simon, I. Rosenman (Paris, France), Ch. Vettier, H. Godfrin, J. Schweizer (Grenoble, France), R. Vangélisti, P. Pernot, A. Perignon (Vandoeuvre-lès-Nancy, France)

Magnetic properties of stage-1 $NiCl_2$–GICs 519
J. T. Nicholls and G. Dresselhaus (Cambridge, MA, U.S.A.)

Magnetic behaviour of a stage-1 $NiCl_2$ graphite intercalation compound 525
M. El Hafidi (Casablanca, Morocco), G. Chouteau and R. Yazami (Grenoble, France)

Magnetic properties of first-stage nickel chloride graphite intercalation compounds 531
S. Flandrois, J. Amiell, B. Agricole (Talence, France), E. Stumpp, C. Ehrhardt and P. Schubert (Clausthal-Zellerfeld, F.R.G.)

Transport properties in magnetic acceptor GICs 537
M. Kinany-Alaoui, L. Piraux, V. Bayot, J.-P. Issi (Louvain-la-Neuve, Belgium), P. Pernot and R. Vangélisti (Vandoeuvre-lès-Nancy, France)

Transport properties of magnetic intercalation compounds 543
K. Sugihara (Funabashi, Japan), I. Shiozaki (Tokyo, Japan), S. M. Sampere, M. Suzuki (Binghamton, NY, U.S.A.), J. T. Nicholls and G. Dresselhaus (Cambridge, MA, U.S.A.)

ESR studies of AsF_5/GICs: comparison of intercalated HOPG and carbon fibers . . . 549
S. Luski, C. Rettori, D. Davidov and H. Selig (Jerusalem, Israel)

Conduction carriers spin resonance experiments in $AlCl_3$–GICs stage 2 reveal an order–disorder phase transition 557
G. Ceotto, G. E. Barberis and C. Rettori (Campinas, Brazil)

Alkali-hydrides graphite intercalation compounds: some electronic studies 563
P. Lauginie, H. Estrade-Szwarckopf, B. Rousseau, J. Conard (Orléans, France), D. Guérard, N. E. Elalem and L. Elansari (Vandoeuvre-lès-Nancy, France)

New results in ^{13}C NMR on GICs 569
M. F. Quinton, C. Frétigny and A. P. Legrand (Paris, France)

^{133}Cs NMR studies on first-stage CsBi–GICs 577
I. Stang, K. Lüders (Berlin, F.R.G.), V. Geiser and H.-J. Güntherodt (Basel, Switzerland)

^{19}F NMR on stage-2 phosphorus fluoride graphite intercalation compounds 583
M. Kraus, I. Stang and K. Lüders (Berlin, F.R.G.)

Spin-lattice relaxation of ^{8}Li in LiC_{12} at low temperatures 589
A. Schirmer, P. Heitjans, W. Faber (Hannover, F.R.G.) and J. E. Fischer (Philadelphia, PA, U.S.A.)

Section VII: Related Layered Intercalation Systems

The design of new low-dimensional solids (Invited) 597
J. Rouxel, A. Meerschaut and P. Gressier (Nantes, France)

Layered double hydroxides pillared by polyoxometalate anions: EXAFS studies and chemical synthesis (Invited) 609
M. Doeuff, T. Kwon and T. J. Pinnavaia (East Lansing, MI, U.S.A.)

Conducting polymers and intercalation (Invited) 617
S. Roth (Stuttgart, F.R.G.)

Intercalation channels in Ag–TiS_2 623
G. R. Carlow, P. Joensen and R. F. Frindt (Burnaby, BC, Canada)

Electrointercalation of Ag into 2H-TaS_2: *in situ* observation of reaction, equilibration and homogenisation 629
C. Ramos, A. Lerf and T. Butz (Garching, F.R.G.)

What determines the phasing of the charge density wave onto the lattice in 1T-TaS_2? 635
P. Ganal, T. Butz and A. Lerf (Garching, F.R.G.)

In situ study of the chemical lithiation of 1T-TaS_2 641
P. Ganal, T. Butz and A. Lerf (Garching, F.R.G.)

Investigation of the nuclear quadrupole interaction of $^{111}In(EC)^{111}Cd$ and ^{181}Hf-$(\beta^-)^{181}Ta$ in the intercalation compound In_xTaS_2 647
W. Olberding, T. Butz and A. Lerf (Garching, F.R.G.)

Investigations of $Mn(pyr)(aq)^{2+}$ and pyridine intercalated $Cd_2P_2S_6$ lattices: mechanism of intercalation and perturbation of the host lattice 653
E. Lifshitz (Haifa, Israel) and A. H. Francis (Ann Arbor, MI, U.S.A.)

Guest–host interactions in hydrated layered chalcogenides as studied by NMR chemical shift anisotropy 659
M. Lobert, H. Möller, W. Müller-Warmuth (Münster, F.R.G.), W. Paulus and R. Schöllhorn (Berlin, F.R.G.)

Intercalation of ammonia and ammonium into host lattices with layered structures 665
W. Nonte, M. Lobert, W. Müller-Warmuth (Münster, F.R.G.) and R. Schöllhorn (Berlin, F.R.G.)

Electrical properties of p-doped highly-oriented polyacetylene 671
D. Begin, J. F. Marêché and D. Billaud (Vandoeuvre-lès-Nancy, France)

Structural variations of highly-oriented polyacetylene upon doping with $GaCl_4^-$ 677
D. Begin, M. Lelaurain and B. Billaud (Vandoeuvre-lès-Nancy, France)

Staging in potassium-doped polyacetylene: *in situ* X-ray diffraction 683
D. Djurado, J. E. Fischer, P. A. Heiney, J. Ma (Philadelphia, PA, U.S.A.), N. Coustel and P. Bernier (Montpellier, France)

Section VIII: Applications and Fibers

Research activities on chemistry of graphite intercalation compounds in Japan 691
M. Inagaki (Toyohashi, Japan)

Tritium behavior in neutron irradiated lithium graphite intercalation compound (LiC_6) 695
T. Terai, Y. Takahashi and N. Akuzawa (Tokyo, Japan)

Low temperature hydrogen absorption on alkali metal–graphite intercalation compounds after ammoniation 701
N. Akuzawa, S. Suzuki, T. Terai and Y. Takahashi (Tokyo, Japan)

Electrochemical GIC sensor for the charge stored in a lead acid battery 707
H. Krohn and F. Beck (Duisburg, F.R.G.)

Alkali doping of α-Fe/graphite–Fe catalysts 713
K. Kałucki and A. W. Morawski (Szczecin, Poland)

GIC formation in neutral aqueous electrolytes — an undesired side-reaction during electrochemical surface oxidation of highly-oriented carbon fibres 719
J. O. Besenhard, J. Jakob, P. Möller, R. F. Sauter (Münster, F.R.G.), A. D. Jannakoudakis (Thessaloniki, Greece) and A. Kurtze (Wattens, Austria)

Lowering the conductivity of carbon fibers by fluorination 725
S. Luski, H. Selig, D. Davidov and C. Rettori (Jerusalem, Israel)

Tensile properties of intercalated pitch mesophase carbon fibers. 733
D. B. Fischbach, M. G. Arnold (Seattle, WA, U.S.A.) and S. Flandrois (Talence, France)

Lithium secondary battery and electric double layer capacitor using carbon fibers electrode 739
M. Endo, Y. Okada and H. Nakamura (Wakasato, Japan)

The effect of length and diameter on the resistivity of bromine intercalated graphite fibers 745
J. R. Gaier (Cleveland, OH, U.S.A.)

Author Index 751

Subject Index 753